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REVIEWS AND ABSTRACTS OF LITERATURE

Behavior of the Lower Organisms. H. S. JENNINGS. *Columbia University Biological Series,* X. New York: The Macmillan Co. 1906. Pp. xiv + 366.

This book is eminently worthy of the excellent series to which it belongs, for it is the most detailed, accurate and complete description, analysis and interpretation of the behavior of lower organisms in existence. More than this, the work stands alone, the first representative of a class of books in which animal behavior is to receive thoroughly scientific treatment.

This review consists of two parts: an objective statement of the contents of Professor Jennings's book and a subjective criticism and evaluation of the same.

The 'behavior of the lower organisms' is divided into three parts, of which the first presents an account of the activities of unicellular organisms, the second a description of the behavior of the lower metazoa, and the third an analysis of the facts of parts one and two with a discussion of certain theories of reaction. The materials of these three parts will be described in turn.

Part I. consists of descriptions of the structure, movements, reactions to stimuli and modifications in behavior of amœba, bacteria, paramecium and other infusoria. Amœba, it is shown, responds to all stimuli which influence higher animals. Its responses, which may be classified as positive reactions, negative reactions and food reactions, are determined as to the nature and direction of movement in part by the location of the stimulus, in part by the internal conditions of the organism. Unequal stimulation of the body causes movement toward or away from the source of the stimulus, whereas a condition of general stimulation induces an irregular contraction without definite movement. Adaptive movements are attained by a process of trial not unlike that seen in higher animals. Or as the author sums up the matter: "The stimulus induces movement in various directions (as defined by internal causes). One of these directions is then selected through the fact that by subjecting the animal to new conditions, it relieves it from stimulation. This is our first example of 'selection from among the conditions produced by varied movements,' —a phenomenon playing a large part, as we shall see, in the behavior of organisms" (p. 22). The reactions of amœba are not stereotyped, but instead vary greatly in correspondence with changes in the condition of the organism as well as in external conditions. There is good evidence of the modification of behavior by experience.

Bacteria are found to exhibit one simple reaction of preeminent importance,—the reversal of the direction of movement. This occurs whenever the organism chances to swim into the region of an unfavorable condition. A stimulus causes not a definitely directed movement away from the source of stimulation as occurs in amœba and in many other organisms, but movement in various directions until finally the stimulus is avoided. Here, as in amœba, success is the result of trial movements, there is 'selection from among the conditions produced by varied movements.'

Paramecium, because of its structure, swims in a spiral course. It reacts to repellent stimuli in a perfectly regular way by swimming backward, turning toward a structurally defined side, the aboral, and then swimming forward in a new direction. If the stimulus be again encountered, the same reaction is repeated. It is important to note that after swimming backward for some distance, in the stimulus-avoiding reaction, paramecium moves so that its anterior end swings about in a circle and thus comes in contact with conditions all around the circle. Whenever a point is reached at which the stimulus is lacking, the organism moves forward in its usual manner. Thus there is a sort of trying or testing of the environment. In addition to the progressive movements of paramecium, many of which may be classed as positive reactions, and the avoiding or negative reactions just mentioned, there are two other forms of reaction: local contractions of the ectosarc and discharge of trichocysts. These latter reactions are relatively unimportant for, as the author points out, the 'action system' of paramecium consists essentially of the swimming in a spiral course, with its features of forward movement, revolution on the long axis, and swerving toward the aboral side. Variations in the relations of a few definite simple movements result in the behavior of this organism.

Professor Jennings gives the following vividly drawn picture of the daily life activities of a paramecium: "An individual is swimming freely in a pool, parallel with the surface and some distance below it. No other stimulus acting, it begins to respond to the changes in distribution of its internal contents due to the fact that it is not in line with gravity. It tries various new positions until its anterior end is directed upward, and continues in that direction. It thus reaches the surface film. To this it responds by the avoiding reaction, finding a new position and swimming along near the surface of the water. Now there is a strong mechanical jar,—some one throws a stone into the water, perhaps. The paramecium starts back, tries certain new directions, and finishes by reacting to gravity in the reverse way from its former reaction; it now swims downward. But this soon brings it into water that is notably lacking in oxygen. To this change it responds as before, trying new conditions till it has come near the surface again. Swimming forward here, it approaches a region where the sun has been shining strongly into the pool, heating the water. The paramecium receives some of this heated water in the current passing from the anterior end down the oral groove. Thereupon it pauses, swings its anterior end about in a circle, and finding that the water coming from one of the directions thus tried is not heated, it proceeds forward in that direction. This course leads it perhaps into the region of a fresh plant stem which has lately been crushed and has fallen into the water. The plant juice, oozing out, alters markedly the chemical constitution of the water. The paramecium soon receives some of this altered water in its ciliary current. Again it pauses, or if the chemical was strong, swims backward a distance. Then it again swings the anterior end around in a circle till it finds a new direction from which it receives no more of this chemical; in this direction it swims forward" etc. (p. 104).

In chapters dealing with the behavior of other infusoria important differences in the activities of members of this group of unicellular organisms are discussed. And, as paramecium is relatively unresponsive to photic stimulation, the reactions to light of stentor and euglena are described in detail. In these organisms reactions to light are caused by changes in the intensity of illumination, and the stimulus is avoided by trial of different directions of movement.

The reactions of infusoria to the electric current differ in principle from those to most other forms of stimulation in that the organism does not try different directions of movement in what appears to be a search for a certain environmental condition, but instead moves now in one way, now in another according to the strengths of action of the current upon the motor organs of different parts of the body. While admitting that it is purely a laboratory product, the author sees fit to describe and discuss the reaction to electric currents and the theories of this reaction in considerable detail.

The presentation of facts of behavior of Part I. is concluded by a chapter on the modifiability of behavior in infusoria, behavior under natural conditions and habits of feeding. Since attached forms are most favorable for the study of these aspects of behavior, stentor furnishes most of the material of the chapter. The behavior of this simple organism is not stereotyped and invariable as has been supposed by many who have discussed animal behavior without studying it, but alters from moment to moment with changes in external conditions and with those changes in internal conditions which result from experience. "The same individual does not always behave in the same way under the same external conditions, but the behavior depends upon the physiological condition of the animal. The reaction to any given stimulus is modified by the past experience of the animal, and the modifications are regulatory, not haphazard, in character. The phenomena are thus similar to those shown in the 'learning' of higher organisms, save that the modifications depend upon less complex relations and last a shorter time" (p. 179).

The mass of facts concerning the behavior of unicellular organisms presented in this part of the book proves conclusively that they, like higher animals, 'prove all things and hold fast to that which is good.'

Part II. deals with the behavior of certain of the multicellular organisms, the lower metazoa, and especially with that of the cœlenterata, the worms and the crustacea. As representatives of the cœlenterata, the behavior of the fresh-water hydra and of the medusa gonionemus is fully described. The action system of each of these organisms is discussed. To strong stimulation the cœlenterata respond by a contraction which tends to remove them from the source of a harmful stimulus and to move them toward the source of a favorable stimulus. Locally acting stimuli produce more or less definitely directed movements according to the strength of the stimulus and the structure of the animal. Both hydra and gonionēmus have a few definite simple reactions, but where these do not meet the demands of the environmental situation other forms of activity, less stereotyped in character, appear. As the author remarks after describing the rejecting reaction of sea anemones: "This whole reaction is characterized by great flexibility and variability. The dēbris sets in operation certain activities; if these do not put an end to the stimulation, other activities are induced, till one is successful. This is an excellent illustration of the general characteristics of behavior in the lower organisms" (p. 203).

In this part of the book facts are adduced in support of the statement often repeated by the author that the internal or physiological states of the organism in large measure determine behavior. In the case of the flatworm planaria, six different conditions of the organism are described, each of which has its appropriate forms of reaction. "The different physiological conditions are determined largely by the history of the individual worm, so that in this sense its behavior may be said to depend on its experience" (p. 253). This statement is true of certain of the crustacea also, for it has been shown that the behavior of crabs and crayfish is modifiable and varies with the conditions to which an individual happens to be subjected. This fact is most strikingly demonstrated in the flatform convoluta, for it has been discovered that this worm migrates downward into the sand of the seashore when the tide rises and upward when the tide falls, and further, that this rhythmic change in reaction occurs even when the tidal changes do not affect the animal. In an aquarium this alternation of downward and upward movement continues for about two weeks, so the worm may be said to retain its habit of reaction for this length of time.

Comparing the behavior of the cœlenterata with that of the protozoa, the author writes: "We find no radical difference between the two. In the cœlenterates there are certain cells—the nerve cells—in which the physiological changes accompanying and conditioning behavior are specially pronounced, but this produces no essential difference in the character of the behavior itself. As in the protozoa, so here, we find behavior based largely on the process of performing continued or varied movements which subject the organism to different conditions of the environment, with selection of some and rejection of others" (p. 230).

Part III. consists of an analysis of the facts concerning the behavior of lower organisms of Parts I. and II., with a discussion of certain of the important theories of behavior and interpretations of the facts considered. In the first two parts of the book Professor Jennings has given a strictly objective account of the activities of many lower organisms; in the third part he considers the relations, origin and significance of the features of behavior which are prominent in these organisms.

There is no essential difference, we are told, between the activities of the protozoa and the metozoa; the behavior of one is no more machine-like than that of the other. Even the possession of a nervous system does not change the nature of behavior. Such are the somewhat startling statements with which this part of the book opens.

An examination of the methods of reaction in unicellular organisms indicates that they do not conform to the demands of the 'local action theory of the tropisms.' Instead of reacting to a stimulus which affects different parts of the body unequally by turning directly toward or away from the side stimulated, most of these organisms with varying degrees of thoroughness try different directions and finally select that in which the influence of the stimulus is either increased or decreased, according as the condition is favorable or unfavorable. Precise orientation, as assumed in the local action theory of the tropisms, either does not occur at all or if it does it is brought about by a process of trial and error instead of by the local action of the stimulus. Of the unicellular organisms it may be said that there is no local contraction or expansion on the side of the organism stimulated, but instead a reaction of the animal as a whole.

But the author goes even further in his attack upon the applicability of this theory of the tropisms and attempts to show that it is of little value even as an explanation of the behavior of the lower multicellular organisms. His words on this subject demand quotation. "We must then conclude from our examination of the facts that for the lower organisms taken into consideration in the present work, the local action theory of tropisms is of comparatively little value for interpreting behavior. This theory uses and attempts to make of general application certain elements here and there observable in the behavior of some organisms. But in many organisms even these elements are almost completely lacking, and in no organism that we have taken up does this theory adequately express the nature of behavior. The tropism as applied to animal behavior in the sense we have considered, is not an elementary factor; it is only a more or less artificial construction, made by combining certain elements of behavior and omitting others that are of most essential significance. It makes use of certain simple phenomena that actually exist, but elevates these into a general explanation of directed behavior, for which they are utterly inadequate. The prevalence of this local action theory of tropisms as a general explanation of behavior in lower organisms is based only on an incomplete knowledge and an insufficient analysis of the facts of behavior" (p. 274).

To the question, is the behavior of lower organisms composed of reflexes? a negative answer is given. If the reflex be defined as an act which is invariable, and this is really the only commonly used definition in objective terms that can be accepted in this connection, it is obviously impossible in the light of the facts of Parts I. and II. to maintain that the behavior of any of the unicellular organisms or of the lower multicellular organisms is made up of simple acts which may be classed as reflex. "The behavior of paramecium and the sea urchin is reflex if the behavior of the dog and of man is reflex . . ." (p. 281). The author, therefore, concludes that the concept of the reflex act as a unit of activity, invariable and unanalyzable, comparable to the atom of physics in certain important respects, is not adequate for the description of the facts of behavior as he finds them.

In chapters on the 'analysis of behavior' the determining factors of behavior, so far as known at present, are discussed in their relations to one another and to the characteristics of the various movements made by lower organisms. These factors are internal and external. Behavior may be determined by any or all of the following five conditions: the present external stimulus; previous stimuli; previous reactions; progressive internal changes; the tendency toward the resolution of physiological states into one another. As a result of analysis "the three most significant features of behavior appear to be (1) the determination of the nature of reactions by the relation of external conditions to the internal physiological processes, and particularly the general principle that interference with these processes causes a change in behavior; (2) reaction by varied or overproduced movements, with selection from the varied conditions resulting from these movements—or, in brief, reaction by selection of overproduced movements; (3) the law of the readier resolution of physiological states after repetition. The first of these phenomena produces the regulatory character of behavior. The second and third furnish the mainsprings for the development of behavior, the second being constructive, the third conservative" (p. 312).

Behavior develops, that is, becomes more effective, more regulatory, in the opinion of the author, by reason of changes in the following directions: (1) increase in delicacy of discrimination; (2) the appearance of reactions to representative stimuli—a stimulus which has no important reaction value becomes the sign of a decidedly beneficial or harmful stimulus and calls forth the reaction which is appropriate to the latter; (3) increase in the complexity and permanency of the modifications produced in the organism by the interaction of external and internal changes; (4) the acquirement of new and more regulatory ways of reacting through selection from among varied movements. "Through the principle of the production of varied movements, and that of the resolution of one physiological state into another, anything that is possible is tried, and anything that turns out to be advantageous to the organism is held and made permanent" (p. 319). Development in accordance with these two principles at times results in the establishment of a fixed response to a certain situation in place of the series of trial movements. Such fixed responses are the reflexes, tropisms, habits and instincts of higher animals. (5) Congenital variations with respect to any of the above changes.

Supposing that the directions of change enumerated should suffice to account for the development of behavior in the individual, how is racial development to be explained? Since the inheritance of acquired characters of behavior has not been proved, this simple method of explanation is not available, although the author admits that the problem of inheritance can not be considered as settled. Natural selection, guided by individual accommodation, serves to account for certain features of racial behavior. Does it account for all? This question the book does not answer. Instead of attempting it the author shows how natural selection might be supposed to bring about the development of behavior in the race.

Regulation in behavior results from the fact that interference with the physiological processes of the organism brings about varied movements which subject the organism to different conditions, one of which relieves the interference and thus causes the changes in behavior to cease. It is, therefore, clear that the fundamentally important principles of regulation are: (1) selection from among a series of trial movements of the one which relieves the organism of conditions which interfere with the physiological processes, and (2) the stamping in, or fixing, of the successful movement through the readier resolution of physiological states after repetition (p. 345).

Professor Jennings believes that there is no gulf between the behavior of lower organisms and the so-called psychic behavior of higher animals. For few, if any, of the objective characters of the behavior of higher animals are lacking in the behavior which forms the subject-matter of this book. "From the lowest organisms up to a man behavior is essentially regulatory in character, and what we call intelligence in higher animals is a direct outgrowth of the same laws that give behavior its regulatory character in the protozoa" (p. 335).

Concerning the existence of consciousness in lower organisms, it is the author's belief that no amount of increase in our objective knowledge can ever solve the problem for us. The problem of the existence of consciousness beyond the self is indeterminate. At the same time it is his opinion that the objective evidence is in favor of the view that consciousness is generally distributed throughout the animal kingdom. "The writer is thoroughly convinced, after a long study of the behavior of this organism, that if amœba were a large animal, so as to come within the every-day experience of human beings, its behavior would at once call forth the attribution to it of states of pleasure and pain, of hunger, desire, and the like, on precisely the same basis as we attribute these things to the dog" (p. 336).

To complete this objective statement concerning the contents of the behavior of the lower organisms, it should be added that the work is admirably illustrated and has a list of the especially important papers on the subject in point at the end of each chapter, as well as an extensive and valuable bibliography of works on the behavior of lower organisms at the end. There is a very complete index to facilitate reference.

Up to this point this review has been merely a statement, in the words of the author so far as possible, of important points made in the book. Were our consideration of the matter to end here nothing would have been accomplished which the author himself could not have done much better. We shall, therefore, turn now to a brief discussion and criticism of the work.

There are two results of Professor Jennings's studies which appear as the central thoughts of the book. One of these is the fact that the behavior of lower organisms is complex, variable and frequently of the trial and error sort instead of being, as has usually been supposed heretofore, simple, invariable and unmodifiable. The other fact is that the local action theory of the tropisms, which has been so extensively used to account for the reactions of lower organisms, does not agree with the facts of behavior in most of the unicellular organisms and in many of the lower multicellular animals, for instead of orienting directly and precisely with reference to a given stimulus by reason of the local action of the stimulus, they usually exhibit a series of trial movements which are the result of the activity of the organism as a whole. The importance of these two general conclusions of the book has not been overemphasized by the author, although he has built his entire work about them and has used all his materials of fact to justify them.

It can not be said that the investigations which have led to these conclusions were entered upon with a prejudice in favor of them, for when the author began his work on the 'Reactions to Stimuli in Unicellular Organisms,' just ten years ago, he laid stress upon the possibility of reducing the seemingly complex activities to simple and relatively uniform acts and used terms in the description of the reactions of the organisms which justify the inference that he believed in the satisfactoriness of the local action theory of the tropisms. But during the ten years between the beginning of his researches and the writing of the 'Behavior of the Lower Organisms,' the accumulation of facts has led to a gradual change in the author's opinion on these matters. To-day he strongly opposes the view that behavior is composed of invariable reflexes which are often determined by the local action of a stimulus.

With reference to the two chief points of the book, the following criticism may be offered. Too little emphasis is given the fact that in many cases what appears to the observer to be a series of trial movements is really the repetition of a certain act. The external effect of the repetition is not precisely the same each time, for the organism is constantly being brought into new relations to its environment. One can not help asking, after all is there not some fundamental difference between the so-called trial movements of unicellular organisms and the trial and error behavior of higher animals?

It is by no means clear that the local action of a stimulus may not give origin to a series of movements which have all the characteristics of trial movements. Orientation to a stimulus, even by local action, is not in all cases precise; the organism moves too far and has to change the direction of motion, or, perhaps because of a conflict of stimuli, it starts to move in the wrong direction. It may well be asked whether the author's opposition to the local action of stimuli may not lead inexperienced investigators to think that all reactions are of the trial and error type. Possibly it would have been better had certain instances of reaction without trial been given greater prominence. Professor Jennings has not disproved the existence of local action: he has shown that the behavior of many of the lower organisms in certain instances need not, and in other cases can not, be explained on the ground of such action. It remains for some one to determine whether a stimulus ever brings about a movement by local action instead of by changing the condition of the entire organism.

Unforunately, the author has not dealt rigorously and in an original manner with the concept of reflex action. The definition which he accepts for purposes of description—an invariable reaction to a stimulus—is obviously unsatisfactory, for if one thing is plain it is that no organic reaction is invariable. Had he either formulated a definition in terms of the results of his investigations or simply said there is no such thing as reflex action as commonly conceived and then proceeded with his careful analysis of behavior, there would have been greater gain. The upshot of the whole matter is that Professor Jennings has no unit of action and apparently is not very hopeful of finding one. He has shown that those acts which are commonly called reflex are far from being simple, in many cases, and are never invariable. The question remains, is there a simple, unanalyzable organic process which may be used for descriptive purposes as a unit of action?

By his researches Professor Jennings has made himself the authority on the behavior of unicellular organisms. His book is admirable with respect to material, method of presentation and form. Its present importance can be fairly judged only when one realizes that it undermines the prevalent conception of the nature of the behavior of lower organisms and narrows to a fraction of its present reach the applicability of the most influential theory of the reactions of lower organisms that has ever been proposed. Its future influence will certainly be tremendous, for it is a work which will determine the direction of research as well as mould popular and scientific opinion. It is the most important book on animal behavior that has ever been written.

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The Psychological Principles of Education. HERMAN HARRELL HORNE, Ph.D. New York: The Macmillan Company. 1906. Pp. xiii + 435.

Considering the present stage of psychological science, Professor Horne has essayed a hazardous task. Though not seeking to contribute to pure psychology nor to special educational methods, he does attempt to deduce practical applications and to criticize educational errors by what he conceives to be ascertained and verifiable laws of mind.

There are five main divisions of the book, the thirty-four chapters, however, being numbered consecutively. Part I. is concerned with the general presuppositions of the science of education, being a revision of his discussion of this topic at the World's Congress of Arts and Sciences at St. Louis. The author pleads for a recognition of education as a science, while admitting that it is primarily an art. Accepting history